Reducing Toxic Exposure from Fish Consumption in Women of Childbearing Age and Urban Anglers: Results of a Two-Year Diary Study

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*This is a living document. A series of manuscripts that will eventually be included in this report are under review by peer-reviewed journals. As these manuscripts are published they will be added to this document and the version number updated. When all manuscripts have been added, the cover will read “Final Version.”

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*The final version of the document will have Appendix A through I.

INTRODUCTION AND SUMMARY

The ultimate goal of this project was to find ways to reduce exposure to toxic substances from Great Lakes fish consumption among women of child-bearing age (WCBA) and urban anglers. The Great Lakes Restoration Initiative Action Plan II identifies these two groups as being at particular risk from exposure to toxic substances from fish consumption. While consuming fish provides important health benefits to women, developing fetuses and children, consuming too much contaminated fish can lead to a variety of problems in children, including birth defects and learning difficulties. In addition, urban waters in industrialized areas may be polluted, and some types of fish in those waters accumulate high levels of industrial contaminants. Urban anglers are considered more likely than other anglers to fish at urban sites and, if they eat the fish they catch, more likely to be exposed to the contaminants in these fish. Consequently, state health departments in the Great Lakes states have made ongoing, long-term efforts to encourage urban anglers and WCBA to continue to eat fish, but within recommended limits.

Part of this effort has included research on how best to communicate messages about risks and benefits of fish consumption to prompt desired behavioral responses. The research has been fruitful in identifying the types of messages and materials that WCBA and urban anglers think would be most likely to encourage them to eat fish within recommended limits. These messages and materials had not yet been tested, however, to determine if they actually influence behavior as intended. This type of testing is important because the process through which communication leads to behavior change is complex; it involves a person receiving messages, correctly understanding them, considering them credible, incorporating relevant information, intending to follow their recommendations, and engaging consistently in the particular behavior (in this case, healthy fish consumption). A message or material may be perceived very positively by representatives of a target audience, but not actually influence behavior as expected. Consequently, we designed a study that would evaluate the impacts of communication of fish consumption guidelines and messages on healthy fish consumption behavior.

To assess behavioral impacts, we conducted a randomized experiment in which we determined the degree to which fish consumption guidelines and materials (developed on the basis of practitioners' insights and past research) reduced the consumption of fish high in toxic substances by WCBA and urban anglers, while still encouraging consumption of fish for the health benefits they provide. We selected a sample of WCBA and urban anglers from the Great Lakes region, gathered detailed information about their fish consumption patterns (including the degree to which these patterns conform to their states' health departments' recommendations), distributed fish consumption messages and guidelines to a randomly selected subset of this sample as an intervention, and gathered detailed information about how these messages and guidelines influenced fish consumption patterns. We hope these results will be used by the Great Lakes states to further enhance their programs to communicate the risks and benefits of fish consumption.

We have organized this report into six sections following the Introduction and Summary. Each section describes an important component of the study. The sections are written as peer-reviewed journal articles, and will appear in this living document as they are published and we

receive permission from the publisher. Currently, one manuscript appears in its entirety (Section 2) and the others list the journals to which the manuscripts are being submitted. The sections are:

- Section 1: Using a Web-based Diary Method to Estimate Risks and Benefits from Fish Consumption
- Section 2: Fish Consumption among Women Anglers of Childbearing Age in the Great Lakes Region
- Section 3: Are Women Anglers of Childbearing Age in the Great Lakes Region Following Fish Consumption Guidelines?
- Section 4: Effects of Narrative Messages to Promote Healthy Fish Consumption Among Women of Childbearing Age
- Section 5: Urban Anglers' Adherence to Fish Consumption Advisories in the Great Lakes Region
- Section 6: Effects of an Advisory Brochure on Fish Consumption of Urban Anglers in the Great Lakes Region

Each section includes footnotes that provide the reader with related information and sometimes reference appendices with more detailed analyses that were beyond the scope of the journal manuscripts. (This information is primarily intended to answer questions raised at the Great Lakes Consortium for Fish Consumption Advisories meeting held in Chicago in March, 2016.) We provide a summary of each section below. We follow these six summaries with a description of the outputs and outcomes of this project.

Summary of Section 1: Using a Web-based Diary Method to Estimate Risks and Benefits from Fish Consumption

Objective: Accurate estimates of the amount and type of fish people eat are necessary to determine the health benefits and risks people face from consuming fish and to assess compliance with fish consumption guidelines. We examine the strengths and weaknesses of using a diary method for collecting such fish consumption information.
Design: We developed a web-based (and mobile phone-enabled) diary methodology to collect detailed fish consumption information for two 16-week periods in the summers of 2014 and 2015.
Participants: We recruited study participants from two populations of licensed anglers living in the Great Lakes region – women of childbearing age (WCBA) and urban residents.
Results: At the end of the first year of data collection, 81% of WCBA and 79% of urban anglers provided at least some fish consumption information. In total, 58% of WCBA and 52% of urban anglers provided complete data across both data collection periods. Among those who provided information at the beginning of Year 2, 97% of both audiences provided information throughout the entire 16-week period. Those who participated throughout the two-year period were older on average (1.9-2.5 years) than other members of our original samples.
Conclusions: Using diaries with web and smartphone technology, combined with incentives and persistent communication, has great potential for assessing fish consumption for situations where the potential risks associated with fish consumption are substantial and the cost can be justified.

The primary limitation of this method is the large cost associated with recruitment and incentive payments.

Summary of Section 2: Fish Consumption among Women Anglers of Childbearing Age in the Great Lakes Region

Objective: Fish consumption advisories are issued by the federal government for women of childbearing age (WCBA). These advisories make recommendations about the amount and types of fish that should be consumed to provide the greatest health benefits to women and their children while avoiding risks from chemical contaminants. Our objective was to describe the fish consumption habits of WCBA anglers and compare their consumption levels with the USDA and (current and proposed) EPA/FDA recommendations.
Design: We used diary methods to study fish consumption patterns for a 4-month period during the summer of 2014.
Participants: We obtained consumption data from 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses, a group which has significant opportunity to eat larger quantities of fish.
Results: Very few members of this group reported exceeding the federal recommendations for total fish consumption (between 3% and 5% depending on assumptions about portion sizes), consumption of canned "white" tuna (0%), or consumption of "do not eat" purchased fish species (4%). WCBA did report eating more fish on average than recent national study estimates, but they did not report consuming as much fish as is recommended to obtain the greatest health benefits of fish consumption. Only 10–12% of study participants reported eating within the recommended range of 8–12oz. of fish per week, with 84–87% eating less than the recommended amount.
Conclusions: Additional efforts are likely needed to encourage WCBA to eat more low-risk fish, even among this group of higher-than-average fish consumers.

Summary of Section 3: Are Women Anglers of Childbearing Age in the Great Lakes Region Following Fish Consumption Guidelines?

Objective: States in the Great Lakes region of the United States issue fish consumption guidelines for women of childbearing age (WCBA) to help them minimize the health risks to themselves and their potential offspring from eating fish contaminated with chemicals. Our objective was to examine the fish consumption patterns of WCBA and determine if WCBA were aware of the guidelines and following them.
Design: We used diary methods to study fish consumption patterns for a 4-month period during the summer of 2014, and a survey to assess awareness of the guidelines.
Participants: We obtained consumption data from 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses.
Results: We found that two-thirds of WCBA reported at least minimal awareness of the fish consumption guidelines issued by the states and federal government, and those that reported awareness were more likely to hold beliefs consistent with the messages emphasized in the guidelines. WCBA reported eating less than one meal/week of fish with most of this fish purchased at a store or restaurant. On average, they consumed just 2.4 sport-caught fish meals over the 16-week study period. The average portion size for sport-caught fish meals eaten by

WCBA was similar to that assumed by states when determining the guidelines. One-quarter of WCBA in our study exceeded the state guidelines for sport-caught and purchased fish, with rates as high as 41% exceeding these guidelines in Michigan and Minnesota.
Conclusions: Additional outreach efforts may be needed to increase compliance with fish consumption guidelines, particularly among subpopulations that exceed the guidelines more frequently.

Summary of Section 4: Effects of Narrative Messages to Promote Healthy Fish Consumption among Women of Childbearing Age

Objective: To test the impact of brochures designed to promote healthy fish consumption among licensed female anglers of childbearing age.
Design: We conducted a randomized, two-wave longitudinal experiment between May 18th, 2014 and September 5th, 2015. Participants reported their fish consumption in summer 2014 via an online diary. We then randomly assigned women to either be sent one of four brochures in spring 2015 using a two (including a short personal narrative or not) by two (using certain or uncertain language) factorial design, or to a fifth, no-exposure control arm. All participants completed a fish consumption diary again in summer 2015. We used ordinary least squares regression to test the effect of the brochures on fish consumption.
Participants: 1,135 women of childbearing age (18 to 48 years of age at baseline) drawn from a sample of licensed anglers who completed an online diary of their fish consumption in both years of the study.
Results: There were no overall effects of randomized condition on fish consumption, driven by low levels of confirmed exposure to the brochure among treatment groups. Among those confirmed to have seen it, however, exposure to brochure versions that included a short personal narrative helped to move women whose levels of fish consumption at baseline were furthest from federally recommended levels closer to these guidelines.
Conclusions: Narratives hold promise as a strategy to effectively convey information about the risks and benefits of fish consumption among women of childbearing age, but more research is needed to identify strategies to maximize exposure to these messages.

Summary of Section 5: Urban Anglers' Adherence to Fish Consumption Advisories in the Great Lakes Region

Objective: Previous research suggests that urban anglers are a group at high risk of being exposed to contaminants from fish consumption. Past studies of urban anglers' fish consumption, however, have had significant limitations making it difficult to generalize their findings broadly and to assess the degree to which urban anglers are complying with advisory recommendations. In three cities in the Great Lakes region, we assessed how much fish urban anglers consumed, whether they complied with fish consumption advisories, and how fish consumption and advisory compliance varied for different demographic groups and in different locations.
Design: We used a diary method to collect detailed information on fish consumption for a 4-month period during the summer of 2014.
Participants: We collected fish consumption data from a representative sample of 1,363 licensed anglers in the three counties containing Rochester, NY, Erie, PA, and Kalamazoo, MI.

Results: We estimated a mean of 1.12 meals/week of fish and 25.1-26.8 grams/day of fish, and the amount of fish consumed varied by no more than 25% from one site to another. Advisory exceedance was more variable, however, ranging from 7-10% to 27-40% in our three study sites. Fish consumption increased with age, education, and income, and was higher for nonwhites than for whites. Advisory exceedance was higher for women, nonwhites, and older anglers. At each site, the types of fish that contributed the most to advisory exceedance varied.
Conclusions: Community-specific (and resource-intensive) fish consumption guidelines are likely to benefit populations of urban anglers.

Summary of Section 6: Effects of an Advisory Brochure on Fish Consumption of Urban Anglers in the Great Lakes Region

Objective: Past research suggests that urban anglers are a group at high risk of being exposed to contaminants from fish consumption. Fish consumption advisories have been used in many regions to encourage healthy fish-eating behaviors, but few studies have been designed to assess whether these advisories actually influence behavior as intended. We conducted a large-scale, randomized experiment to test the influence of an advisory brochure on urban anglers' fish consumption.
Design: We collected detailed information on urban anglers' fish consumption in the summers of 2014 and 2015. We provided a treatment group with fish consumption guidelines in an advisory brochure before the summer of 2015 and compared their change in fish consumption to a control group.
Participants: We collected fish consumption data from a representative sample of 1,041 licensed anglers in the three counties containing Rochester, NY, Erie, PA, and Kalamazoo, MI.
Results: The brochure led to a reduction in fish consumption for anglers who ate the most fish; these anglers reduced their consumption of high-contaminant purchased fish and both high- and low-contaminant sport-caught fish. The brochure also reduced sport-caught fish consumption among those anglers who exceeded the advisories in 2014. In addition, the brochure led to small increases in fish consumption in urban anglers who ate very little fish.
Conclusions: Fish consumption guidelines brochures can have effects on target audiences. Future research that could improve our understanding of the effects of such interventions might assess the effects of brochure interventions on contaminant ingestion, explore the effectiveness of different delivery methods for brochures, or explore the effectiveness and cost-effectiveness of different types of interventions.

OUTPUTS AND OUTCOMES

This project produced a number of outputs that will contribute to longer-term outcomes. These outputs and outcomes are summarized here for both women of childbearing age and urban anglers.

Women of Childbearing Age (WCBA)

The principal outputs of the WCBA portion of the project were:

- We developed a set of print brochures intended to encourage women to eat fish, but to follow healthy fish-eating guidelines. These print brochures were informed by the results of past research, by a survey and a set of focus groups conducted as part of this project, and by the experience and insights of health professionals and staff members of state health departments and environmental agencies in the region.

- We collected detailed diary-based fish consumption information from women of childbearing age in the Great Lakes region over 4-month periods in the summers of 2014 and 2015. In 2014, 1,395 provided information on their fish consumption for the entire 4-month period. In 2015, 1,173 provided information for the entire period. Combining data from the two years, 1,135 WCBA provided information on their fish consumption for the entire 4-month period in both years.

- We estimated the number of WCBA eating fish in excess of recommendations and the number of WCBA eating less fish than is recommended to receive health benefits. Three to five percent of WCBA exceeded federal recommendations for total fish consumption, 0% exceeded federal recommendations for canned "white" tuna, and 4% consumed one or more meals of federal "do not eat" species. Rates of exceedance of state fish consumption guidelines, which include sport-caught fish, were much higher. One-quarter of WCBA exceeded the state guidelines, with rates as high as 41% exceeding the guidelines in Michigan and Minnesota. A total of 84-87% of WCBA ate less fish than was recommended by the USDA and (current and proposed) EPA/FDA guidelines to receive health benefits.

- The 1,135 women who completed fish consumption diaries throughout the 4-month periods in both years of the project were included in the experiment in which we tested the impacts of an advisory brochure on fish consumption. Approximately two-thirds of the women received one of four versions of the brochure, and the remaining one-third served as a control group. The brochure increased the amount of fish that women ate without increasing the number exceeding advisory recommendations. Therefore, it increased the number of women getting benefits from fish consumption without increasing the number at risk from fish consumption. Women who ate the least fish (< 0.7 meals/week at baseline) stood to benefit the most from increasing their fish consumption. In our study, women who ate < 0.7 meals/week of fish and received fish consumption guidelines with messages about the importance of eating fish ate more fish the next year. However, this benefit only occurred if they received messages in a "narrative" format (messages communicated as part of a story about a hypothetical woman of childbearing age); other forms of the guidelines did not influence fish consumption. These women increased their fish consumption largely by eating more low-mercury, purchased fish. These women did not increase their consumption of more contaminated fish.

- Women who ate too much fish (>2.8 meals/week at baseline) were also influenced by the narrative form of the brochure. They ate fewer meals after receiving the brochure, but did not decrease their consumption sufficiently to be within advisory recommendations.

The principal outcomes of this portion of the project were:

- We documented how healthy fish consumption and ingestion of toxic substances through fish consumption changed over the two-year course of this project in response to the advisory brochure (as described above).

- The principal outcome of this work was intended to be a reduction in the number of WCBA who eat Great Lakes fish in excess of recommended consumption guidelines and, therefore, accumulate toxic substances in their bodies. Our intervention did not lead to a reduction in the number of women eating purchased or sport-caught fish in excess of guidelines. It did, however, lead to an increase in fish consumption by WCBA without a corresponding increase in the number of WCBA exceeding the guidelines. Consequently, it increased the benefits women are getting from fish consumption without increasing the risks. Furthermore, a few women who were exceeding the recommended guideline of 2 meals per week decreased their consumption somewhat.

- Based on these findings, we estimate for every 10,000 narrative brochures distributed, 2,797-3,330 women of childbearing age would eat more fish, totaling 14,544-17,316 more fish meals each year. This increase in fish consumption would not result in any more women exceeding fish consumption guidelines. Furthermore, we estimate for every 10,000 narrative brochures distributed, 76-90 women of childbearing age who were currently exceeding fish consumption guidelines would eat fewer fish, totaling 1,011-1,197 fewer fish meals each year. These estimate are based on the fish consumption messages and methods of distributing the brochures used in this study. The distribution methods (and possibly the messages) used in advisory programs would differ.

Urban Anglers

The principal outputs of the urban angler portion of the project were:

- We developed a set of print brochures intended to encourage urban anglers to follow fish consumption guidelines. These print brochures were informed by the results of past research and by the experience and insights of health professionals and staff members of state health departments and environmental agencies in the region.

- We collected detailed diary-based fish consumption information from urban anglers living in three sites in the Great Lakes region over 4-month periods in the summers of 2014 and 2015. In 2014, 1,363 provided information on their fish consumption for the entire 4-month period. In 2015, 1,081 provided information for the entire period. Combining data from the two years, 1,041 urban anglers provided information on their fish consumption for the entire 4-month period in both years.

- We estimated the number of urban anglers eating fish in excess of advisory guidelines. Advisory exceedance ranged from 7-10% to 27-40% in our three study sites (with the range reflecting different assumptions). Advisory exceedance was higher for women, nonwhites, and older anglers.

- The 1,041 urban anglers who completed fish consumption diaries throughout the 4-month periods in both years of the project were included in the experiment in which we tested the impacts of an advisory brochure on fish consumption. Approximately two-thirds of the sample received one of four versions of the brochure, and the remaining one-third served as a control group.

- The brochure led to a reduction in fish consumption for anglers who ate the most fish; these anglers reduced their consumption of purchased fish, sport-caught fish, high-contaminant purchased fish and both high- and low-contaminant sport-caught fish. (We defined "high-contaminant fish" as those for which guidelines recommend fewer than one meal/week.) The version of the brochure did not matter.

- The brochure also led to a reduction in sport-caught fish consumption by those anglers who exceeded advisory recommendations in 2014. These anglers reduced their consumption of sport-caught fish compared to the control group by nearly 2 fish over the course of the summer.

- The brochure led to small increases in fish consumption in urban anglers who ate very little fish. These anglers increased their consumption of sport-caught fish and high-contaminant purchased and sport-caught fish. These increases in fish consumption came without increasing the number of anglers who were exceeding advisory recommendations.

The principal outcomes of this portion of the project were:

- The principal outcome of this work was intended to be a reduction in the number of urban anglers who eat Great Lakes fish in excess of recommended consumption guidelines and, therefore, accumulate toxic substances in their bodies. Our intervention led to a reduction in consumption of high-contaminant fish (fish for which guidelines recommend fewer than one meal/week) among anglers who ate the most fish.

- Based on these findings, we estimate for every 10,000 brochures distributed, the 1,948-2,452 anglers eating the most fish would reduce their consumption of high-contaminant fish by 6,457-8,127 meals each year. Similarly, the 2,504-3,048 anglers eating the most purchased fish would reduce their consumption of high-contaminant purchased fish by 4,780-5,818 meals each year, and the 1,120-1,532 anglers eating the most sport-caught fish would reduce their consumption of high-contaminant sport-caught fish by 3,381-4,625 meals each year. At the same time, high-consuming anglers would also reduce their consumption of low-contaminant sport-caught fish. The 2,133-2,651 anglers eating the most sport-caught fish would reduce their consumption of low-contaminant sport-caught fish by 5,629-6,996 meals each year. These estimates are based on the fish consumption

messages and methods of distributing the brochures used in this study. The distribution methods (and possibly messages) used in advisory programs would differ.

- Although high-consuming anglers would reduce their consumption of fish, anglers who ate very little fish would increase their consumption of high-contaminant fish. The 668-1,004 anglers who ate the least purchased fish would increase their consumption of high-contaminant purchased fish by 786-1,181 meals each year. The 3,661-4,255 anglers who ate the least sport-caught fish would increase their consumption of high-contaminant sport-caught fish by 4,023-4,675 meals each year. Because these anglers ate almost no fish initially, increasing their consumption of high-contaminant fish by these small amounts would pose very little risk to them. Thus, communication of fish consumption guidelines would allow anglers who were at low risk to take additional advantage of their opportunities to eat fish.

SECTION 1: USING A WEB-BASED DIARY METHOD TO ESTIMATE RISKS AND BENEFITS FROM FISH CONSUMPTION

Submitted to Risk Analysis

SECTION 2: FISH CONSUMPTION AMONG WOMEN ANGLERS OF CHILDBEARING AGE IN THE GREAT LAKES REGION*

ABSTRACT: Fish consumption advisories are issued by the federal government for women of childbearing age (WCBA). These advisories make recommendations about the amount and types of fish that should be consumed to provide the greatest health benefits to women and their children while avoiding risks from chemical contaminants. We used diary methods to study fish consumption patterns of 1,395 WCBA in the Great Lakes coastal region who purchased fishing licenses, a group which has significant opportunity to eat larger quantities of fish. Very few members of this group reported exceeding the federal recommendations for total fish consumption (between 3% and 5% depending on assumptions about portion sizes), consumption of canned "white" tuna (0%), or consumption of "do not eat" species (4%). They did report eating more fish on average than recent national study estimates, but they did not report consuming as much fish as is recommended to obtain the greatest health benefits of fish consumption. Only 10 to 12% of study participants reported eating within the recommended range of 8 to 12 oz. of fish per week, with 84-87% eating less than the recommended amount. Additional efforts are likely needed to encourage WCBA to eat more low-risk fish, even among this group of higher-than-average fish consumers.

KEYWORDS: fish consumption; fish consumption guidelines; anglers; risk communication; women of childbearing age

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1. Introduction

Fish consumption advisories are issued by state, federal, and tribal agencies in part because of the potential health risks to women and their children from a variety of chemical contaminants (Turyk et al., 2012: Papadopoulou et al., 2014). These advisories recommend that women of childbearing age (WCBA) limit their consumption of certain fish. At the same time, many of these agencies recommend that women consume more low-risk fish, especially during and after pregnancy, emphasizing fish with lower concentrations of chemical contaminants, particularly mercury. Fish are the primary dietary source of omega-3 fatty acids, which are important for adult health (Domingo, 2014) as well as the development of eyes, brains, and nervous systems in the fetus (Innis, 2008).

Several agencies within the federal government offer advice to women. The United States Department of Agriculture (USDA) advises that "women who are pregnant or breastfeeding consume at least 8 and up to 12 ounces of a variety of seafood per week, from choices lower in methyl mercury" (USDA, 2010, p. 39). Current Environmental Protection Agency/Food and Drug Administration (EPA/FDA) advice suggests that WCBA "eat up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury" (USEPA, 2004, p.1). However, EPA/FDA are in the process of revising their recommendations to more closely follow the USDA advice. The draft advice proposed by the EPA/FDA suggests that WCBA "eat 8 to 12 ounces of a variety of fish each week" from choices that are lower in mercury (USFDA, 2014, p. 1). The key difference is a change from suggesting it is permissible for WCBA to eat *up to* 12 ounces to suggesting women *should* eat 8 to 12 ounces. This change encourages consumption.

Advice from all federal agencies suggests that WCBA limit their consumption of certain fish that are higher in mercury. The recommendation is to limit canned "white" tuna consumption to 6 oz. per week, and avoid consumption of four species of fish (swordfish, shark, tilefish, and king mackerel).

While all states offer advice about consumption of fish caught by anglers within state waters, some states also offer advice regarding purchased fish. This advice generally follows the federal recommendations but offers more details and suggestions about specific species to consume (e.g., MDHHS, n.d.). Some states provide more conservative advice than the federal government, particularly for the consumption of canned "white" tuna. For example, Minnesota and Wisconsin suggest one serving per month (MDH, n.d.; WDHS, 2008) compared to the federal advice of 6 oz. per week.

Several studies have found that most WCBA avoid consumption of the most contaminated fish (Lando et al., 2012; Silver et al., 2007), however they do not seem to be following the advice encouraging consumption of low-risk fish and therefore may be missing out on the benefits of fish consumption for themselves and their offspring. Connelly et al. (2014) found that almost all new mothers consume less fish during pregnancy than was recommended by USDA. Similarly, Lando et al. (2012) found in a national survey that on average, all major demographic groups of women, but especially pregnant women, ate less fish than was recommended. Among women who ate fish, the median intake was 1.8 oz/week for pregnant women, 2.5 oz/week for postpartum women, and 3.0 oz/week for WCBA who were not pregnant or postpartum. Each of

these medians is far below the recommended 8 to 12 oz/week. Mahaffey et al. (2009) used National Health and Nutrition Examination Survey (NHANES) data from 1999-2004 to examine fish consumption patterns of WCBA (and their association with blood mercury levels). They found that WCBA in the Great Lakes coastal region ate less than 1 meal/week of fish on average, far below the recommended 2 meals/week. Based on more recent NHANES data (2009-2010), among those who ate fish nationwide, 60% ate less than 0.75 meals/week and 40% ate 0.75+ meals/week (EPA, 2013). A survey of Great Lakes states' residents found that among the 83% of women who ate fish, 6% consumed more than 2 meals per week, 14% consumed 1 to 2 meals/week, and the remaining 80% consumed less than 1 meal/week (Imm et al., 2005). None of these studies specifically examined the fish consumption patterns of women who fish, however. Women anglers likely have additional opportunities to consume fish, including potential exposure to additional chemical contaminants found in the fish they catch. Their consumption rates are likely to be higher than women who do not fish. Knobeloch et al. (2005) found that women who lived in a household where someone had a fishing license did eat more meals of sport-caught fish. Therefore, they may be more likely to get the benefits as well as be exposed to the risks of fish consumption.

We studied WCBA in the Great Lakes coastal region who purchased fishing licenses (and therefore have the opportunity to fish legally). Specifically, we recruited WCBA anglers who indicated that they consumed fish at least occasionally to participate in a diary study in which they reported their fish consumption behaviors. Because our objective was to describe the fish consumption habits of WCBA anglers living in this region, we did not include WCBA who did not eat fish. Among fish-consuming WCBA, this angler WCBA group may be likely to have higher levels of fish consumption than typical WCBA. Specifically, we examined how much and what types of fish they reported consuming and compared these levels with the USDA and (current and proposed) EPA/FDA recommendations.

2. Materials and methods

2.1 Sample selection and diary recruitment

We drew a sample of 15,000 fishing licenses sold to women aged 18 to 48 (who would reach a maximum age of 50 [considered the end of the childbearing years] at the end of our two-year study[1]) who lived in counties bordering the Great Lakes (i.e., Great Lakes coastal region). We drew the sample by state in proportion to the number of licenses sold in each state to WCBA who lived in the Great Lakes coastal region[2].

We sent invitation letters to each member of the sample in February 2014. The letter described the study and what would be required of participants. It also offered a financial incentive up to $20 for participation in the project, and provided a link to a sign-up page on the Internet. We provided a postage-paid return postcard for people to opt out of the study because they did not eat fish, did not have regular Internet access, or were not interested in participating. We sent a follow-up letter to all invitees a week later encouraging participation.

[1] We report only data from the first year of the study in this paper.

[2] Appendix B provides information on results from a special sample of Minnesota WCBA who were recruited as part of another research project and not included in the results of the main body of this report.

We made telephone calls to those who did not sign-up or return a postcard to encourage participation and allow sign-up directly over the telephone. Calling ceased in a particular state when the quota of participants had been reached for that state. During the study sign-up process we obtained email addresses and then checked them by sending out a study participation verification email. Email was then used for all communication with study participants.

2.2 Diary data collection

We collected fish consumption information for 16 weeks from May 18 through September 6, 2014. Participants recorded data in two-week blocks. Participants could record information as many times as they wished during the two-week period. Every two weeks we sent an email invitation to participants to signal the start of the next two-week period and remind them that the previous two week-period was ending. When a two-week period ended, we sent up to three reminders to participants who had not completed entering data for the period to finish recording their information for the period. Participants earned financial incentives for each period completed and received a bonus at the end if they completed reporting for every period.

We gave each participant a link unique to them to access their personal fish consumption diary on the Internet. On the initial page, participants saw information for the eight two-week periods of the study, showing completed periods and incentives earned. On the next page we asked participants to record whether or not they ate fish on each day in the current two-week period. For each day they indicated they ate fish, another page opened asking the number of fish meals they had eaten on that day. For each meal reported, participants recorded whether the fish was purchased (at a store or restaurant) or sport-caught (i.e., fish caught by you or someone else), the species eaten, the portion size, and (for sport-caught fish) where the fish was caught. We provided a list of fish species, including the most commonly consumed purchased fish and those with consumption guideline recommendations, along with a text box to record species not on the list. For sport-caught species, we listed only those with consumption guideline recommendations and provided an "other" option. Participants indicated portion size in reference to a picture of a 6 oz. cooked (170 grams) portion of salmon (Fig. 1); we asked participants if the meal they ate was larger, smaller, or the same size as the picture.

We obtained data on participant age from fishing license records. We gathered data on other socio-demographic characteristics, such as education and race, using an online survey conducted during the last 2-week period of diary data collection[3].

2.3 Data analysis

Several previous studies have estimated the size of fish portions that people consume using pictures similar to those used in our study (Connelly et al., 1996; West et al., 1989) or plastic models (Silver et al., 2007). Since we provided a picture of a 6 oz. cooked salmon meal, we assumed those indicating an equivalent portion to the photo ate a 6 oz. portion (170 grams). For 14% of meals, the participants indicated their portion size was larger than the picture; we assumed they ate 8 oz. (227 grams). For meals reported as being smaller than the picture (47% of meals), we used a sensitivity analysis to compare two options for calculating portion size. For one option, we estimated the smaller portion size to be 3 oz. (85 grams) and for the other we

[3] We did not ask if they fished during the study period.

Fig. 1. Picture shows a 6 oz. piece of cooked salmon (8 oz. pre-cooked).

assumed the size to be 4 oz. (113 grams). We used these estimates to convert from the number and size of meals to an estimate of ounces and grams consumed per week or per day.

We analyzed data from the diary using SPSS (IBM SPSS Statistics 20). We used chi-square tests to identify statistically significant differences between states at the $P < 0.05$ level. Any differences described in the narrative text are statistically significant at this level. We used Scheffe's test to identify differences in portion sizes based on species of fish consumed. We used linear regression to explain differences in fish consumption based on available demographic data.

We report state-specific data unweighted so these values reflect the number of WCBA who participated from that state. We weighted all other reported data in proportion to the number of fishing licenses sold to WCBA in the Great Lakes coastal region of each state. Weighting factors ranged from 0.85 to 1.17.

3. Results

3.1 Diary recruitment and participation rates

We recruited 2,014 WCBA to participate in the study. Women who agreed to participate were slightly older (35.5) than other women in the sample pool (33.7, $p<0.001$). Participation in the first two-week period was 80%. The number who participated throughout the 16-week study period was 1,419 (70%). WCBA were selected to participate in this study because they indicated that they ate fish at least occasionally. However, a few participants (n=24) reported that they did not consume any fish during the 16-week study period and were thus excluded from the analysis. We found no differences in fish consumption between those who participated fully and those who participated during only part of the study period for the periods when the two groups overlapped. Women of childbearing age who participated the entire 16 weeks were slightly younger than those who did not (35.7 vs. 36.9, $p=0.042$). Since these differences were substantively small, we considered WCBA who participated throughout the 16-week period as similar to all women who participated in the study and report results for the 16-week group only (n=1,395).

By design, women in our study ranged in age from 18 to 48. The average participant was 36 years old. Most were white (95%) and half (52%) reported they had a college degree. The median household income was in the $50,000 to $75,000 range. Eleven percent reported earning less than $25,000 per year, and 7% reported earning more than $150,000. Half of the participants (51%) reported having children 15 years of age or younger living in their household.[4]

3.2 Fish consumption

3.2.1 Types of fish eaten

Participants consumed over 20,000 meals during the 16-week study period, of which the vast majority (82%) were purchased fish (i.e., fish purchased at a store or restaurant). The proportion of meals from sport-caught fish (i.e., caught by the WCBA angler or someone they know) varied by state, with the lowest proportion of sport-caught meals consumed in Illinois and the highest proportion consumed in Minnesota (Fig. 2).

WCBA consumed a variety of purchased fish and shellfish (Table 1)[5]. Most of the more frequently eaten species, such as shellfish and salmon, are considered to have low mercury levels. (We defined "low mercury level" as <0.05ppm, which is equivalent to the unrestricted category in the Great Lakes protocol [McCann et al., 2007]. Mercury concentrations in fish were taken from the FDA list of commercial fish and shellfish [FDA, 2014]). Species low in mercury, highlighted in bold type in Table 1, comprise roughly two-thirds of meals consumed. Shellfish (e.g., shrimp, crab, scallops, and clams) alone comprise about one-third of purchased meals consumed. Shellfish consumption was particularly common among New York and Ohio WCBA (35% of meals) but less so among Minnesota WCBA (26%). Salmon, canned "light" tuna, canned "white" tuna, and cod were among the other most frequently consumed fish. Canned tuna, both varieties, was particularly common in Minnesota ("light" 18% and "white" 11% of meals). Canned "white" tuna was also somewhat common in Indiana (11%), but less so in Ohio (5%). Cod made-up a greater proportion of meals in Wisconsin (15%) than in the other states. Haddock, while not commonly eaten in most states, was most frequently eaten in New York (12% of purchased meals consumed).

The average portion size varied considerably by type of fish (Table 1). Canned tuna, both varieties, were the smallest in average portion size. Fish sticks/fast food sandwiches, shellfish, and tuna (not canned) portions were slightly larger. Salmon, the most commonly consumed single species, was intermediate among the types of fish examined, but average portion size was still smaller than the 6 oz. picture shown to participants. Women reported eating sport-caught fish and purchased haddock, perch, and catfish in significantly larger portions, averaging close in portion size to the picture shown.

[4] At the end of the study, we asked about pregnancy and breastfeeding status during the study period. Only 53 of the 913 respondents to the question indicated they were pregnant or breastfeeding during the period. We concluded the sample size was too small to assess how pregnancy and breastfeeding influenced fish consumption.

[5] Appendix C characterizes the number of types of purchased fish that individuals consume.

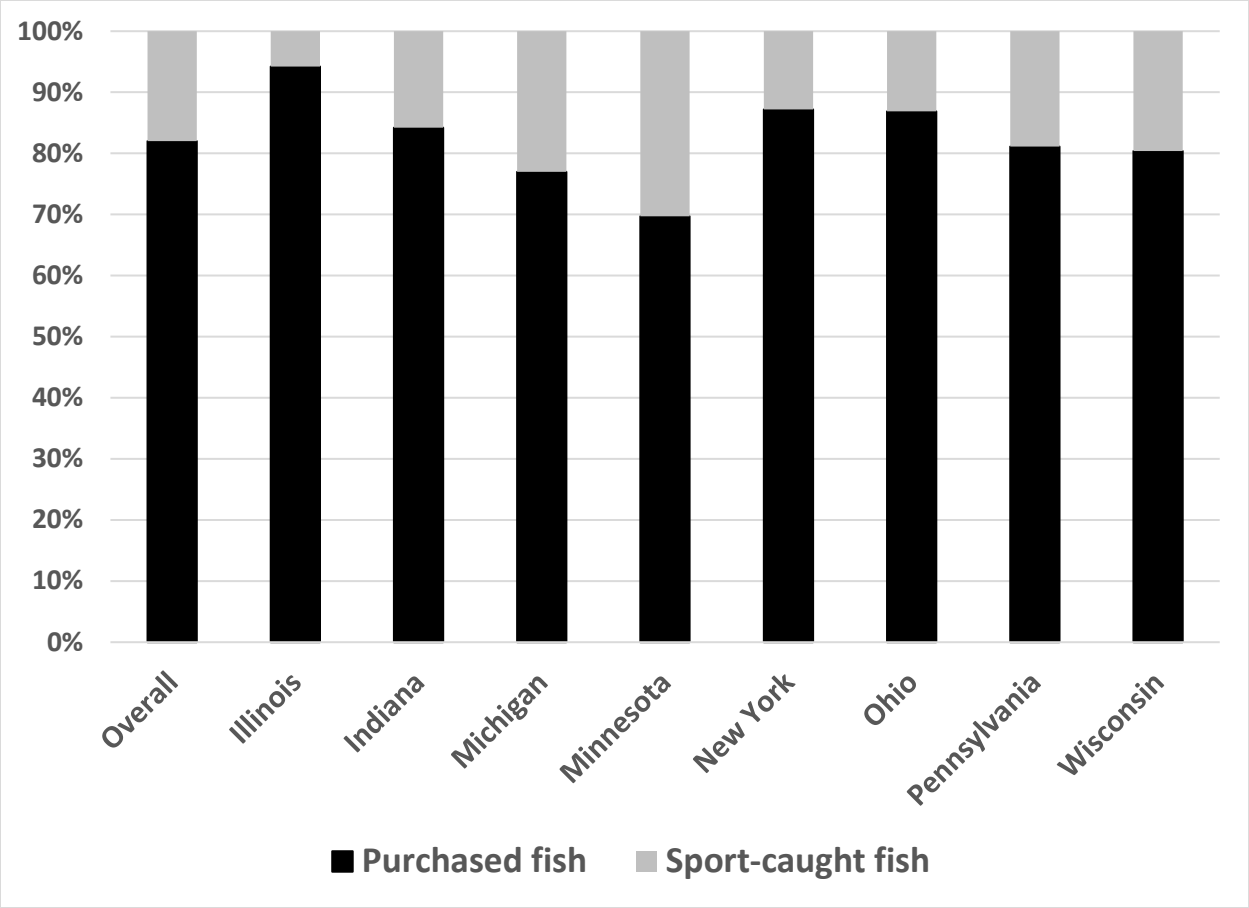

Fig. 2. Percentage of meals that were purchased versus sport-caught, overall and by state (Statistically significant difference between states at $p \leq 0.05$ using chi-square test).

3.2.2 Amount of fish eaten

The number of meals reported eaten during the 16-week period ranged from 1 to 92. The median was 12 meals or 0.75 meals/week. The average was 0.93 meals/week and did not differ by state of residence. A regression model using available demographic data showed that consumption increased as age and education level increased (adj. $R^2 = 0.041$, Table 2). Consumption was also higher among non-white WCBA and those without children age 15 or younger living in the household. Using the model coefficients to predict levels of consumption among the demographic groups reporting the highest fish consumption, the model predicts that older, highly educated, non-white women without children living at home averaged 1.5 fish meals/week.

Table 1
Percent of purchased meals and portion sizes for all meals by type of fish eaten (bolded species are considered low in mercury).

Type of Fish Eaten	% of purchased meals	Portion Size (Grams) based on*	
		3, 6, 8 oz. (85,170,227 grams)	4, 6, 8 oz. (113,170,227 grams)
Shellfish	30.4	131[c,d,e]	146[c,d]
Salmon	13.6	138[d,e,f]	150[d,e]
Canned "light" tuna	9.7	103[a]	125[a]
Cod	7.8	155[g,h,i]	156[f,g,h]
Canned "white" tuna	7.6	109[a.b]	129[a,b]
Tilapia	5.5	144[e,f,g]	154[d,e,f]
Fish sticks/fast food sandwiches	3.9	121[b,c]	138[b,c]
Haddock	3.1	163[i]	171[h]
Tuna (not canned)	2.7	130[c,d]	144[c,d]
Catfish (farm-raised)	1.4	161[i]	169[h]
Perch (purchased)	1.0	160[i]	168[h]
Other types of purchased fish	13.3	145[f,g,h]	163[e,f,g]
Sport-caught	N/A	157[h,i]	166[g,h]

* Used two options for calculating portion size if the participant indicated the meal was smaller than the 6 oz. portion pictured. Assumed 8 oz. if they indicated the meal size was larger.
[a-h] Values without a letter in common are significantly different from each other at p = 0.05 using Scheffe's test.

When portion size was factored in, WCBA anglers in the Great Lakes region reported consuming on average between 18.3 (using a more conservative assumption) and 20.1 (using a more liberal assumption) grams per day (g/day). As with the number of meals, the average grams per day consumed did not differ by state of residence. However, individual daily fish consumption varied considerably, with half of the WCBA eating 15.2 to 17.2 g/day or less (Table 3). Ten percent of WCBA consumed more than 35.4-38.4 g/day, almost double the average daily consumption; 1% consumed more than 67.8-73.3 g/day.

Table 2
Demographic predictors of fish consumption (meals/week).

Variable	Coefficient	*p*-value
Intercept	0.81	<0.001
Race[a]	- 0.29	<0.001
Age	0.01	<0.001
Child age 15 or younger in household[b]	- 0.21	<0.001
Education[c]	0.03	0.026

[a]Dummy variable (1=white, 0=non-white).
[b]Dummy variable (1=child age 15 or younger living in the household, 0= no child age 15 or younger in household)
[c]Education level was measured on a 6-point scale from 1=less than high school to 6=graduate degree. Income was also a significant predictor, but dramatically reduced the sample size if included in the model. It was highly correlated with education (0.31).

Table 3
Individual average daily fish consumption for WCBA who were at each consumption percentile.

Percentile of Women of Childbearing Age (WCBA)	Grams per day based on portion sizes of*	
	3, 6, 8 oz. (85,170,227 grams)	4, 6, 8 oz. (113,170,227 grams)
25%	8.9	10.1
50%	15.2	17.2
75%	24.0	26.3
80%	27.1	29.9
90%	35.4	38.4
95%	42.3	46.0
99%	67.8	73.3

* Used two options for calculating portion size if the participant indicated the meal was smaller than the 6 oz. portion pictured. Assumed 8 oz. if they indicated the meal size was larger.

Fish consumption patterns of those eating the most fish differed little from those eating fewer meals. Those eating the most fish (top 10%) did not eat more fish that the federal government recommends against eating than those who ate fewer fish meals. They consumed slightly more

meals from species low in mercury than those who ate fewer fish meals (56% versus 50% of fish meals), and somewhat fewer sport-caught fish (16% versus 19% of fish meals)[6].

3.2.3 Adherence to federal guidelines

EPA/FDA guidelines recommend that WCBA eat up to 12oz. of a variety of fish and shellfish each week. Assuming 6 oz. is a standard meal size, this recommendation is for up to two meals per week. Few women in our study reported consumption levels exceeding the recommendation by any of the metrics we used (Table 4). Five percent reported consumption levels exceeding the recommendation based on the number of meals consumed. Three to four percent exceeded the recommendation based on portion size.

The federal guidelines also recommend that WCBA eat no more than 6 oz. of canned "white" tuna per week. Although 29% of women in our study ate canned "white" tuna during the study period, none reported consuming more than the recommended amount. Consumption varied somewhat by state of residence, with Minnesota women who ate canned "white" tuna consuming twice as much per week as New York women (1.7 versus 0.7 oz. per week).

Table 4

Percent of WCBA in each meal category using three measures of fish consumption.

	Measures of fish consumption		
Meals (oz.)/week	# of meals	3, 6, 8 oz portion size	4, 6, 8 oz portion size
0.5 (3oz.) or less	29.3	38.9	33.6
0.51 (>3oz.) to 1.0 (6oz.)	36.6	36.5	38.0
1.01 (>6 oz.) to 1.5 (9oz.)	18.9	15.5	17.0
1.51 (>9oz.) to 2.0 (12oz.)	10.0	6.0	7.7
2.01 (>12oz.) to 2.5 (15oz.)	2.4	1.8	1.9
2.51 (>15oz.) or more	2.8	1.3	1.8

Very few WCBA in our study (4%) ate fish that the federal government recommends against (i.e., swordfish, shark, tilefish, king mackerel). Swordfish was the most commonly consumed "do not eat" fish, followed by shark. Only one participant reported eating tilefish, and none reported consuming king mackerel. Among women who ate these fish, 78% reported eating only one meal of the "do not eat" fish during the 16-week study period.

Federal and state advisories also discuss the benefits of fish consumption. Current EPA/FDA guidelines suggest women eat up to two meals of fish lower in mercury per week to receive the benefits. While at least two-thirds of the fish consumed are species considered low in mercury, Table 4 shows that most WCBA did not consume the recommended amount of fish (i.e., 2 meals per week). The vast majority of women ate less than 1.5 meals per week (85%), and most ate less than 1 meal per week (66%). Only 12% reported eating in the range of 2 meals per week (1.5-2.5

[6] Appendix D profiles the top 10% of fish consumers in more detail.

meals). The USDA and the proposed EPA/FDA guidelines suggest that WCBA consume between 8 to 12 oz. of fish per week. Only 10-12% of our study participants reported eating fish within that range.

4. Discussion and Conclusions

Our findings suggest several implications for communicating with WCBA about fish consumption to gain desirable health benefits while guarding against health risks from chemical contaminants in fish. Messages about the healthiest fish to consume should be tailored to locally popular fish, whether sport-caught or purchased. Species of purchased fish consumed by WCBA varied significantly, even within the eight-state region of the Great Lakes. Species like canned tuna made up a greater proportions of the meals consumed by women in Minnesota, whereas shellfish and haddock were more frequently consumed in New York.

Messages in fish consumption advisories should emphasize the health benefits and importance of fish consumption, encouraging consumption of low-contaminant species. Even though there was variation in species consumed within the Great Lakes region, the total amount of fish consumed did not vary. Average consumption was consistent at 0.93 meals/week across the region, much lower than federal advice for desired consumption. Some demographic sub-groups (older, more educated, non-White WCBA without children age 15 or younger living in the household) reported consuming more fish, patterns consistent with findings from previous research (e.g., EPA, 2013; Knobeloch et al., 2005; Lando et al., 2012; Traynor et al., 2013). Even among these sub-groups, however, our model estimated an average of 1.5 meals/week, a rate of fish consumption which is still lower than federal advice.

Although state fish consumption guidelines are often focused strongly on sport-caught fish from within-state, recommendations should be included regarding purchased fish, focusing on the health benefits of eating fish while affirming advice about species to avoid or limit. Among WCBA in our study, most of the fish consumed were purchased fish, not sport-caught fish. Several states do currently offer advice for purchased fish, and in some cases the advice is more detailed than the federal advice, including recommendations for fish with moderate mercury levels (e.g., MDH, n.d.).

Very few members of this audience exceeded the federal recommendations for consumption of canned “white” tuna (0%), or consumption of “do not eat” species (4%), similar to the findings of Lando et al. (2012) in a national study, and Silver et al. (2007) in a study of low income WCBA in the California Sacramento-San Joaquin Delta. We also found very few WCBA exceeding the recommended limit for total fish consumption (3-5%), similar to Lando et al. (2012). These findings suggest that at the broad population level there does not appear to be a need for greater attention to risk messages beyond reinforcing the guidance that already exists.

Messages about purchased and sport-caught fish should focus on eating a certain amount of fish to obtain the benefits from fish consumption for WCBA and their potential offspring. Very few women (10-12%) in our study were eating the recommended amount of fish averaged over the 16-week study period, with 84-87% eating less than the recommended amount. Mahaffey et al. (2009) came to a similar conclusion studying WCBA who lived in the same geographic area as our sample, but who did not necessarily fish. They found using data from the NHANES study

that WCBA ate on average less than 1 meal/week of fish. Using more recent NHANES data (2009-2010), the EPA (2013) reported that among those who ate fish, 60% of WCBA nationally ate less than 0.75 meals/week.

WCBA living in the Great Lakes region who were anglers were consuming more fish on average than national estimates for WCBA in the summer months when sport-caught fish consumption would be expected to be highest due to favorable conditions for fishing and increased recreational opportunities. The EPA (2013) reported average consumption for those who ate fish was 12.8 g/day, calculated from 2009-2010 data presented in the report, compared with our estimate of 18-20 g/day. However, this was still not enough fish for women to obtain all the health benefits for themselves and their potential offspring.

Enhanced outreach efforts appear to be necessary to focus on encouraging more WCBA to eat more low-risk fish. Other researchers have suggested this as well (Bloomingdale et al., 2010; Lando et al., 2012; MDH, 2012; Teisl et al., 2011). We recommend focusing future research on measuring actual behavior change among women of childbearing age exposed to different messages that encourage consumption of low-risk fish. WCBA are not eating enough fish to maximize the potential for health benefits, even among this group of anglers who may have the greatest opportunity and inclination to eat larger quantities of fish.

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SECTION 3: ARE WOMEN ANGLERS OF CHILDBEARING AGE IN THE GREAT LAKES REGION FOLLOWING FISH CONSUMPTION GUIDELINES?

Submitted to Journal of Great Lakes Research

SECTION 4: EFFECTS OF NARRATIVE MESSAGES TO PROMOTE HEALTHY FISH CONSUMPTION AMONG WOMEN OF CHILDBEARING AGE

Submitted to Public Health Nutrition

SECTION 5: URBAN ANGLERS' ADHERENCE TO FISH CONSUMPTION ADVISORIES IN THE GREAT LAKES REGION

Submitted to Journal of Great Lakes Research

SECTION 6: EFFECTS OF AN ADVISORY BROCHURE ON FISH CONSUMPTION OF URBAN ANGLERS IN THE GREAT LAKES REGION

Submitted to Risk Analysis

APPENDIX B: RESULTS FROM NORTHERN MINNESOTA WOMEN OF CHILDBEARING AGE SPECIAL SAMPLE

The Minnesota Department of Health (MN DOH) conducted a related study in northern Minnesota. The MN DOH recruited twenty-six WCBA for that study, not necessarily anglers, to participate in the diary as a separate sample. Complete results from that sample are listed in all tables as "MN (special sample)" in the Year 1 report to the Consortium (Connelly et al. 2015). We present a summary of the most relevant findings below.

Sixteen of the 26 Northern Minnesota WCBA recruited provided information throughout the Year 1 study period. (One WCBA provided partial information and is not included in the following results.) We compare WCBA in the special sample (n=16) to WCBA from Minnesota living in counties bordering Lake Superior who participated in the larger diary study (n=69) in the tables below.

Table B-1. Select socio-demographic characteristics by study strata.

	Percent with children aged 15 or younger in household	Percent white	Mean age
Minnesota	36.4	98.5	33.0
MN (special sample)	32.2	100.0	32.6

Table B-2. Education level by study strata.

	Percent		
	H.S. diploma or less	Some college	College degree or more
Minnesota	4.5	39.4	56.1
MN (special sample)	35.7	35.7	28.6

Table B-3. Average number of meals consumed during study period (total, purchased, and sport-caught) and the proportion of meals that were sport-caught by study strata.

	Average number of meals consumed during study period			% Sport-caught
	Total	Purchased	Sport-caught	
Minnesota	14.6	10.2	4.4	32.5
MN (special sample)	12.1	7.1	4.9	33.7

Table B-4. Most popular purchased fish meals by study strata.

	Percent of purchased fish meals					
	Shellfish[1]	Salmon	Canned light tuna	Canned white tuna	Cod	Haddock
Minnesota	25.7	16.5	18.3	11.1	4.0	1.0
MN (special sample)	8.8	9.6	20.2	13.2	12.3	3.5

[1] Shellfish included as examples shrimp, crabs, scallops, and clams.

Table B-5. Percent exceeding the fish consumption guidelines, as defined for our study and the primary species associated with exceeding the guidelines by study strata.

	Percent exceeding guidelines[1]	Primary species associated with exceeding the guidelines
Minnesota	33-41	Canned "white" tuna, walleye.
MN (special sample)	19-25	Canned "white" tuna.

[1] Estimates are presented as ranges because some advice is based on the length of the fish caught; if consumers did not know the length of the fish they ate then we estimated their consumption assuming both the most and least conservative consumption recommendations

Twelve Northern Minnesota WCBA participated in the second year of the project. They did not receive a version of the experimental brochure that contained the narrative. Therefore, no analysis could be done to see if these women consumed more fish in Year 2, similar to the findings of the larger group that received a narrative version of the brochure.

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APPENDIX C: DO INDIVIDUALS EAT A VARIETY OF PURCHASED FISH?

We found that WCBA, on average, ate 4.1 different purchased species over a 16-week period, with a range of 1 to 13 species. Thirteen percent ate only one species over a 16-week period.

We found that urban anglers, on average, ate 4.7 different purchased species over a 16-week period, with a range of 1 to 16 species. Ten percent ate only one species over 16-week period.

Note: The surveys did not distinguish between various forms of shellfish (shrimp vs. scallops, etc.). Therefore, the analyses above treat all shellfish as one species, and thus may underestimate the variety of seafood species consumed.

Table C-1. Number of different purchased fish species eaten during a 16-week period by WCBA and urban anglers.

	Percent	
Number of different purchased fish species eaten	WCBA	Urban anglers
1	12.8	10.4
2	14.5	11.4
3	17.4	14.6
4	17.1	15.3
5	13.4	15.0
6	9.7	11.2
7	6.8	8.8
8	3.9	5.4
9	2.1	4.1
10	1.3	1.6
11	0.8	0.7
12	0.1	0.8
13	0.1	0.3
14	0.0	0.3
15	0.0	0.0
16	0.0	0.1

APPENDIX D: WOMEN OF CHILDBEARING AGE: PROFILE OF TOP 10% OF FISH CONSUMERS AND OF WOMEN WHO EXCEED FISH CONSUMPTION GUIDELINES

Table D-1. Socio-demographic characteristics of WCBA who were among the top 10% of fish consumers or were among those who exceeded the guidelines in Year 1.

	Percent	
Socio-demographic characteristics	**Top 10% of fish consumers**	**Those exceeding liberal guidelines**
Age		
18-29	21.1	22.6
30-39	34.5	37.0
40-49	44.4	40.4
Race		
White	89.1	93.5
Non-white	10.9	6.5
Education level		
H.S. or less	8.8	7.4
Some college	39.0	45.5
College degree	39.0	33.5
Graduate or professional degree	13.2	13.6
Household income		
< $25,000	9.1	14.4
$25,000-$49,999	18.2	17.9
$50,000-$74,999	15.9	19.7
$75,000-$99,999	23.9	22.2
$100,000-$149,999	19.3	16.6
$150,000 +	13.6	9.2
Might get pregnant in next 5 years	33.5	32.6
Children 15 or younger in the household	38.7	45.0

Table D-2. Percent of purchased and locally-caught meals eaten by WCBA in Year 1, by those who ate the most meals (top 10%) versus others.

	Percent of meals	
Fish meals eaten in Year 1	**Top 10% of fish consumers**	**Other 90% of fish consumers**
Locally-caught fish	15.8	18.7
Purchased fish	84.2	81.3
Shellfish	25.9	24.7
Salmon	14.7	9.9
Canned “light” tuna	5.8	8.6
Cod	4.8	6.9
Canned “white” tuna	5.0	6.6
Tilapia	5.7	4.1
Fish sticks/fast food sandwiches	2.2	3.5
Haddock	1.9	2.7
Tuna (not canned)	2.8	2.0
Catfish (farm-raised)	2.3	0.8
Perch (purchased)	0.6	0.9
Other purchased fish	12.5	10.6